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(54) A submersible reservoir for storage and transportation of fluids

(57) The reservoir has a plurality of storage vessels (1), ballast tanks (2) and buoyancy tanks (3) encased in concrete (5) and surrounded by a casing (6). The tanks and vessels extend over substantially the whole length of the reservoir, except for end sections. The reservoir has a towing eye (8) which enable it to be towed, preferably underwater, and may be provided with its own propulsion unit. The ballasting is such that the reservoir can selectively float or sink when the storage vessels are empty, or full.

An underwater docking facility is also disclosed, for the storage vessels.

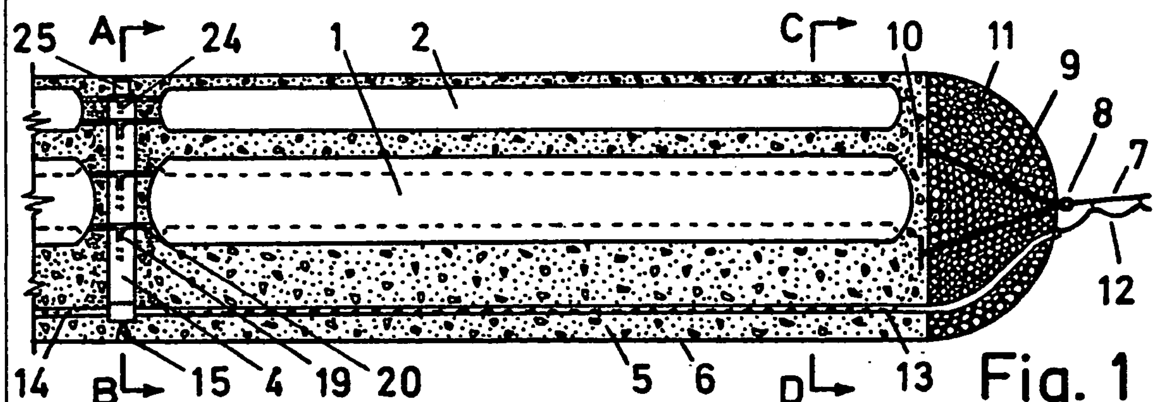

Fig. 1

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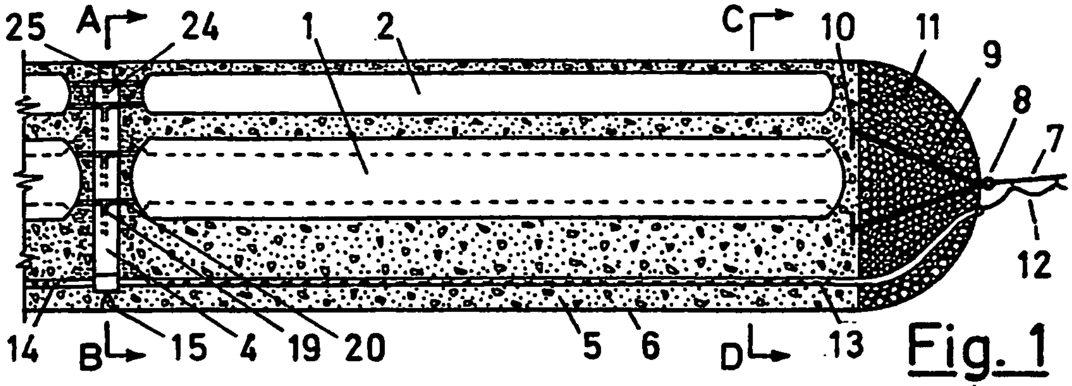

Fig. 1

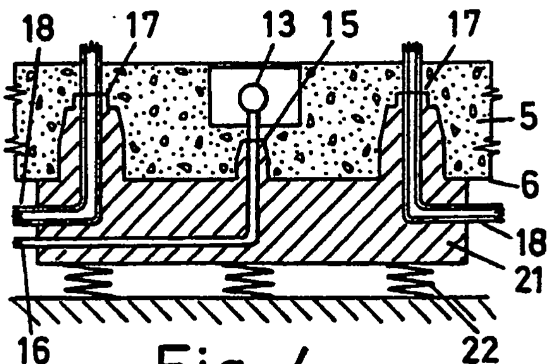

Fig. 4

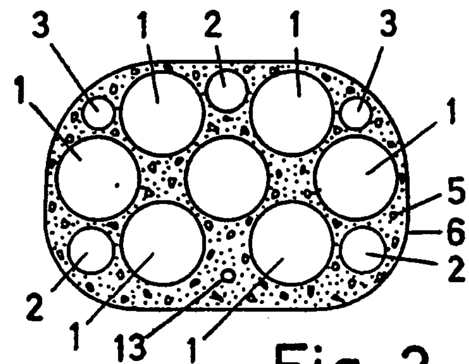

Fig. 2

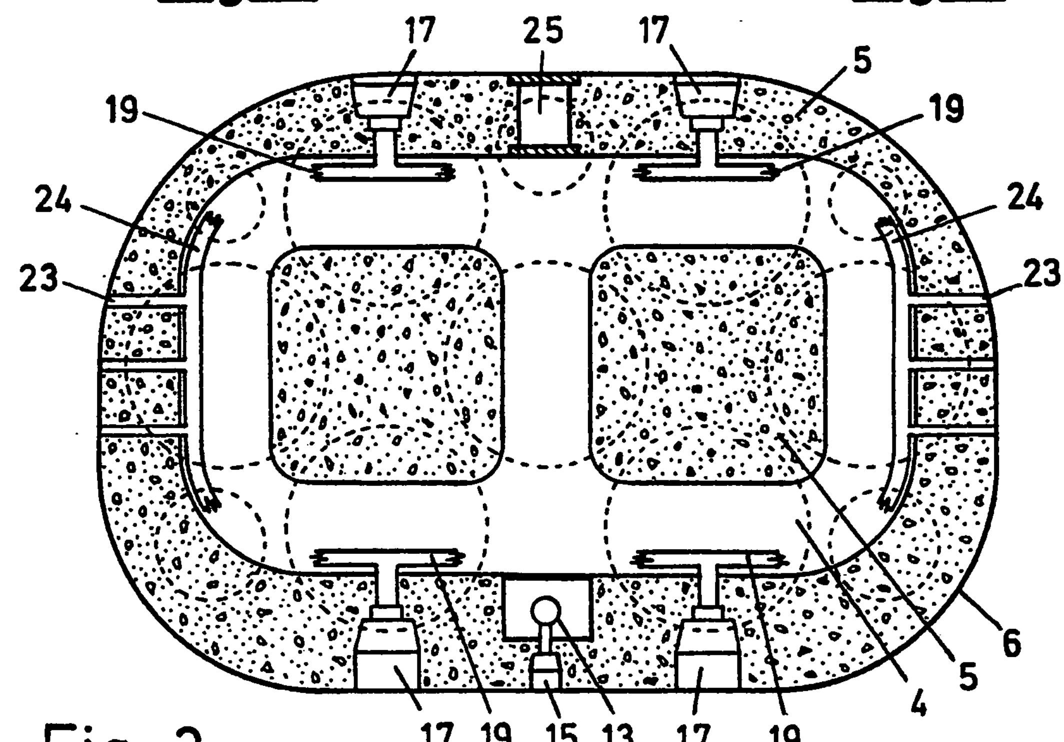

Fig. 3

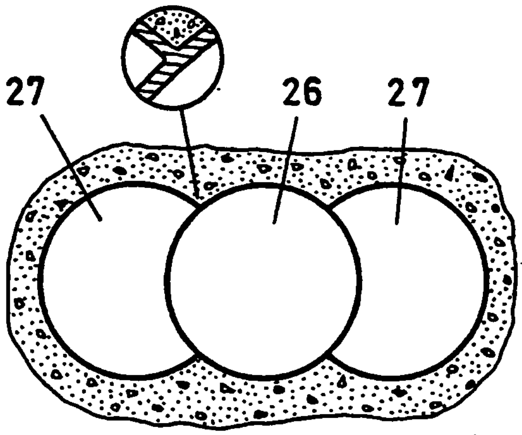

Fig. 5a

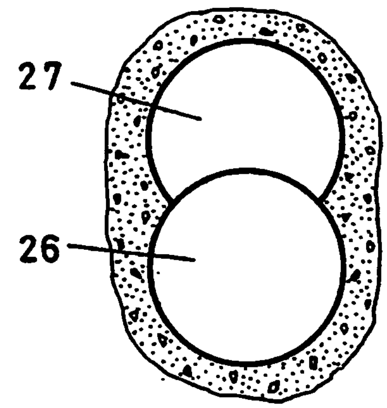

Fig. 5b

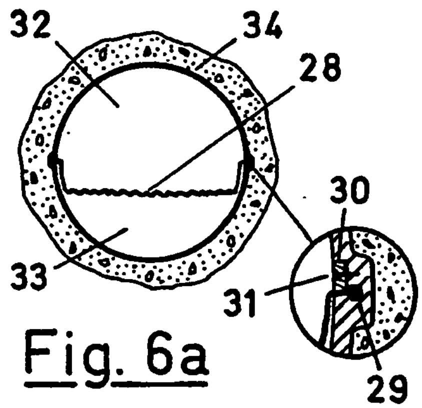

Fig. 6a

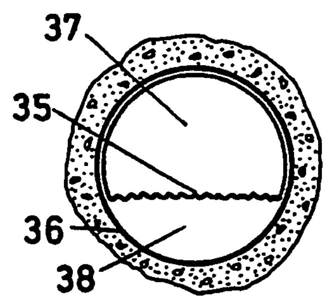

Fig. 6b

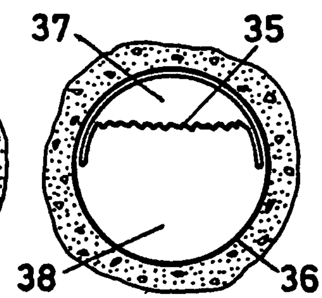

Fig. 6c

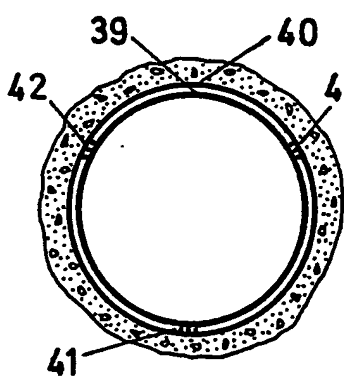

Fig. 7a

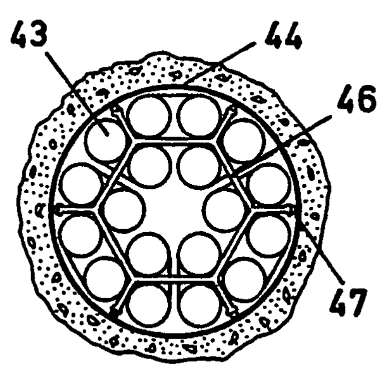

Fig. 7b

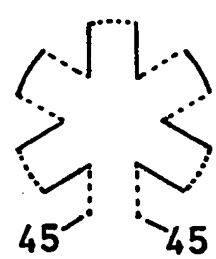

Fig. 7c

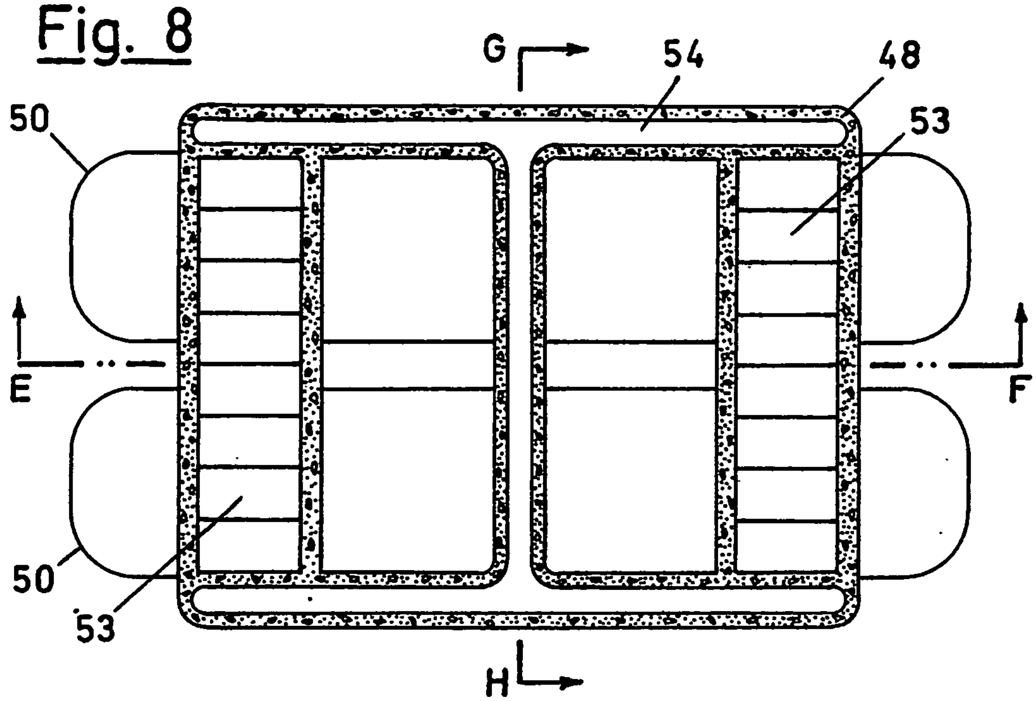

Fig. 8

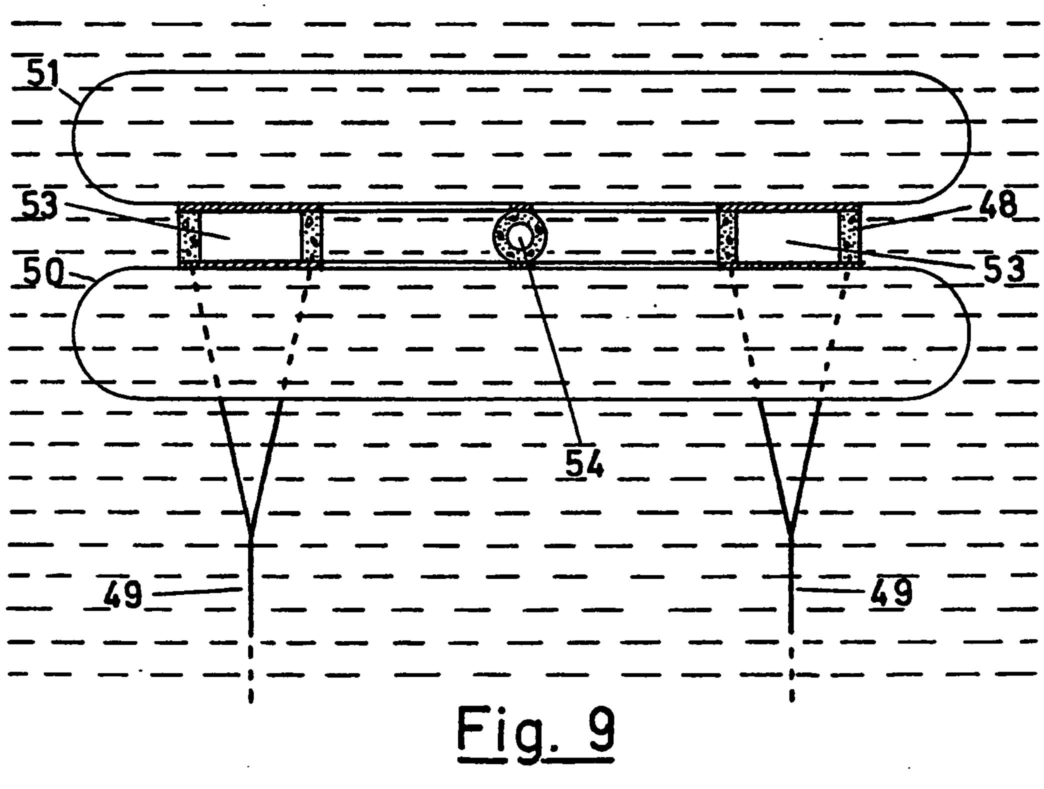

Fig. 9

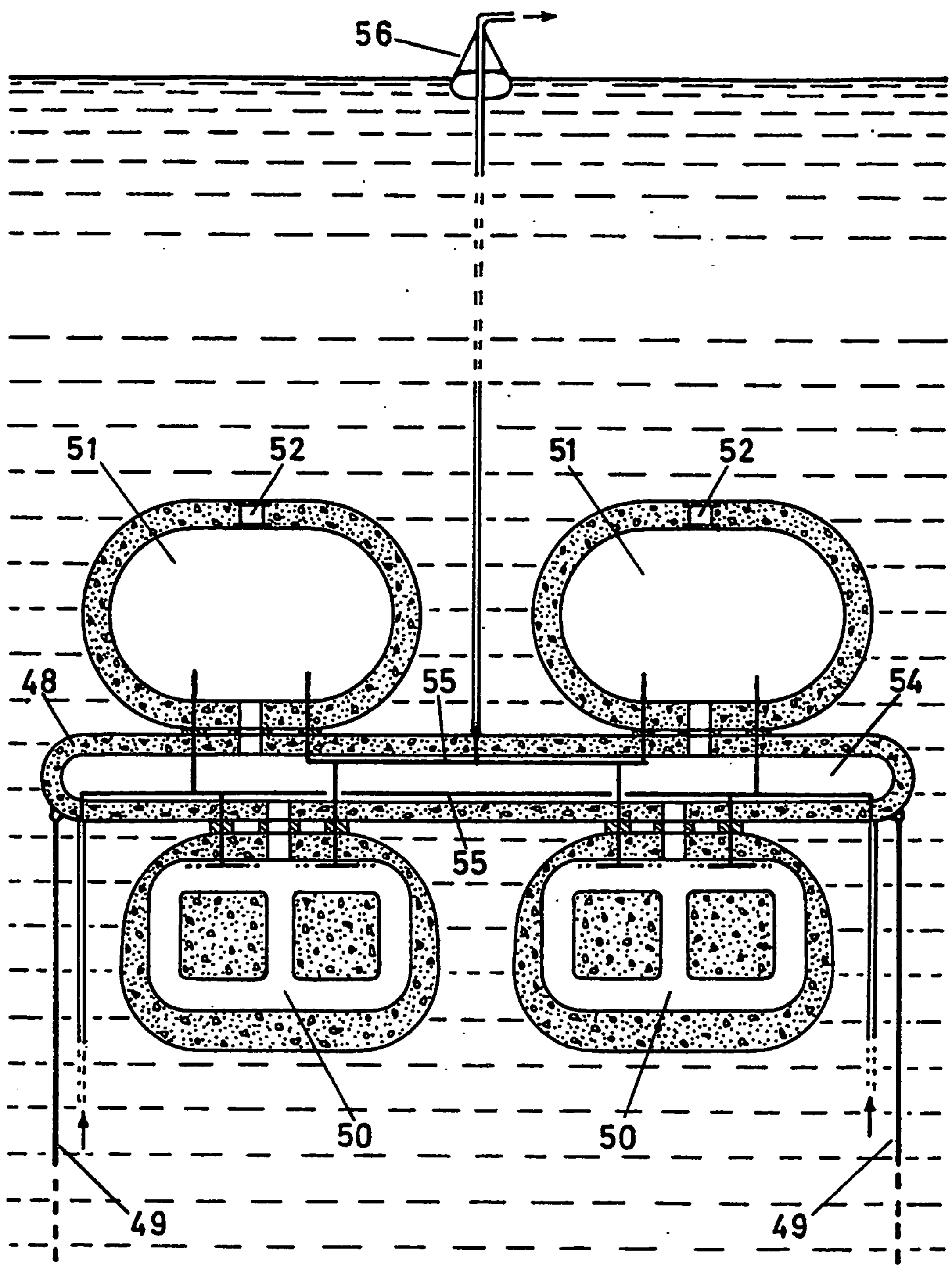

Fig. 10

SPECIFICATION

A submersible reservoir and an underwater berthing facility for storage or transportation of a fluid

The invention relates to the storage and transportation of fluids in the environment of the sea of other body of water. The term "fluid" as used herein is intended to include liquids, gases, slurries and gases in conjunction with liquids or slurries.

The transportation by sea of large quantites of fluids as required for example in bringing ashore oil and natural gas from wells at sea and in supplying fuel and fresh water to islands, is accomplished using undersea pipelines and tankers. The economic viability of each method and the choice between them depends on the nature and value of the fluid, the amount that has to be transported in a given time, the transportation distance, the need for continuity of transportation, and the location of other transportation requirements for the same and other fluids. There are many instances where although the quantities to be transported are large, they are insufficiently large for existing methods to be economically viable. This is especially so in the case of hydrocarbon natural gas which has a low commercial value per unit volume, requires deep refrigeration for liquifaction to reduce its volume, and is commonly flared (burnt) when produced in association with oil production. This practice, which wastes a natural resource, is giving rise to increasing concern throughout the world resulting in a need for cheaper methods of collection.

When shuttle tankers are used to bring oil ashore, storage facilities are required at the production platform. Oil storage tanks are sometimes provided in the base and legs of fixed platforms, but the depth in which such platforms can be used is limited, and construction costs increase as the depth of water increases. Alternatively, storage can be provided by floating facilities such as a moored tanker or an anchored spartype storage and loading terminal, and these are the kinds of storage facilities normally used in conjunction with semi-submersible production platforms. However, with the depletion of the more readily accessible undersea deposits of oil and gas, the oil industry is moving towards developing the resources in deeper offshore areas where weather conditions are more hostile. Consequently, increasing attention is being given to developments in which some or all of the production facilities are placed underwater. In such locations it may be difficult or unsafe to use the existing kinds of storage facilities.

An oil production system recently under consideration within the oil industry that has relevance to the invention here presented is a system known as the 'Single Well Oil Production System' or 'SWOPS', (see Shell Briefing Services, Number One, 1983 entitled "The Offshore Challenges" distributed by the Royal Dutch/Shell Group). The concept of the system is that a tanker lowers a 'riser' ro a wellhead on the sea bed; by remote control the riser is connected to the wellhead, the wellhead turned on, then after taking on board fluids from the well the wellhead is turned off and the riser disconnected. The system is intended for extended production testing of a subsea hydrocarbon field. It may also be used for production from a comparatively small field, but without separate storage facilities the well can only be productive when there is moored over it an operational tanker with processing plant on board.

Turning to another kind of relevant problem, large quantities of hoxious waste fluids may be produced by some industrial processes, or by accidents in such processes, that cannot be safely released into the environment or treated at source, and these fluids may need to be transported by sea to another place for treatment or disposal. Freighters, tankers, or barges may be used, but here also there may be problems with the cost of transporting gas that can only be liquified with deep refrigeration. Or if the fluid is highly toxic, the risk of exposing the crew to danger or of a towed barge breaking loose in a storm and being wrecked may be unacceptable.

According to the invention there is provided a reservoir for storage or transportation of a fluid, comprising at least one vessel for receiving the fluid, means for allowing the fluid to be supplied to and withdrawn from the vessel or vessels, and at least one ballast tank, the ballasting being such that regulation of the amount of ballast permits the reservoir selectively to float or sink when the vessel or vessels is or are empty.

The invention is intended to provide in some circumstances, a less costly or a less perilous method of storing and transporting fluids at sea and close in-shore off mainland coasts and islands, or in navigable rivers. In a preferred form a self-contained reservoir is proposed that incorporates one or more storage vessels within a rigid enclosed structure. Water-ballast tanks of sufficient volume enable the reservoir to float or sink when empty and, preferably, when full of a cargo of a fluid or fluids. Preferably the reservoir is provided with the means for changing automatically the amount of ballast water contained within the body of the reservoir so that during loading and unloading of a cargo of fluid underwater, the submerged weight of the reservoir is approximately constant and small in magnitude with either a positive or negative buoyancy as required. Preferably the overall shape of the reservoir and the arrangement and shapes of the storage vessels and water-ballast tanks

within it are such that the dead weight of the reservoir together with anything it contains, and the buoyancy force of the water displaced by the reservoir are distributed in such a way over the plan area of the reservoir that for both the conditions of floating at the surface and submergence, the upward and downward forces of buoyancy and weight respectively are moderately well balanced against each other however much fluid cargo the reservoir contains. By these two means, namely the control of the amount of ballast water, and the controlled distribution of weight and buoyancy, it is possible to employ large storage reservoirs that may settle on a hard uneven sea or river bed without risk of damage to the structure of the reservoir while avoiding the need to construct a reservoir capable of withstanding very large bending moments and shearing forces. Also by keeping the submerged weight low regardless of the amount of fluid cargo it contains, any underwater berth designed to hold the reservoir during loading or unloading will not be subjected to large forces. Not only does this enable a light structure to be used to berth the reservoir on the sea or river bed with the avoidance of foundation problems, but also it is possible to use a berth with negative submerged weight anchored down to any required depth in the water without the need for excessively large buoyancy forces and anchorage forces that otherwise would have to be employed in such a kind of berth. Preferably the reservoir is provided with the means by which it may be berthed underwater automatically such as water jets on the reservoir which may be varied in intensity and direction and which are controlled by sensing devices attached to the reservoir and on the berth. It is desirable that in addition to such automatic control there should be provided remote manual override in conjunction with underwater television cameras mounted in or on the reservoir and in or on the berth. If required the reservoir may be provided with other means of self-propulsion, steerage, and depth control all remotely controlled. The preferred method for moving the reservoir from one location to another, empty or containing a cargo of fluid, is by towing for which purpose the reservoir is provided with suitable means for attaching a tow line. The reservoir may be towed on the surface, but preferably it is towed underwater with remote control of its depth in the water and reverse thrust as required to keep the tow line taught. Preferably the reservoir is also provided with attachments for mooring the reservoir when surfaced or submerged, and with lifting eyes to raise the reservoir should the water-ballasting system fail when the reservoir is submerged. If required, the reservoir may be provided with replaceable energy-absorbing shields to provide some protection against accidental damage.

A number of advantages for different kinds of use are offered by the invention. It may provide an economic method for the collection of natural gas from subsea wells where the yield is insufficiently large to justify the cost of transmission by pipeline, or of liquifaction while awaiting collection by a shuttle tanker. If a government in granting concessions for oil recovery imposes a condition that the associated gas must not be flared but brought ashore, the use of the invention may prove to be advantageous even if the saleable value of the gas does not cover the cost of bringing it ashore. With the depletion of the more accessible reserves of oil and gas and an increasing need for subsea production in waters that are too deep for sea-bed storage or where the weather conditions are too hostile to use floating storage facilities, the invention offers a method for storing oil and gas at any suitable depth which may be below the depth of wave action or at a depth that is free from damage by icebergs where these occur. In shallower waters where sea-bed storage is possible the low submerged weight provided by the invention avoids any need for extensive preparation of the sea bed which is especially advantageous if the reservoir is used in rocky locations. The invention may provide a more economical method for supplying fuel and fresh water to an island in the process of development, and to arctic coasts for the purpose of extracting minerals, where the provision of submerged storage may offer the additional advantage of preventing the cargo of fuel and water freezing. The use of concrete to construct the body of the reservoir makes it particularly suitable for containing radio-active fluid. If such waste or any other kind of noxious fluid is being transported in the reservoir under tow and the sea becomes stormy, the tow line may be released if the water is not very deep and the reservoir sunk to bottom without risk of damage, there to await collection when conditions are calmer. The invention also offers the prospect of advantages with expected developments in the oil industry, namely the increasing use of subsea production facilities and the operational development of the Single Well Oil Production System (SWOPS). The berthing of storage and production facilities at a comparatively shallow depth in deep water and the remote coupling of a SWOPS riser may enable a fully operational platform to be established underwater safe from storms, icebergs, and shipping, and avoiding the need to flare associated gas at the surface or pump it back into the oil-bearing beds. Or the underwater storage facility may simply be used with SWOPS tankers, leading to more efficient use of the tanker and continuous production from the well.

In the accompanying drawings:

Figure 1 is a part longitudinal section

through one form of submersible reservoir which may be symmetrical about AB or provided with a propulsion and guidance unit at one end (not shown);

Figure 2 is a cross-section to the same scale through the reservoir of Fig. 1 on CD;

Figure 3 is a cross-section to a larger scale through the reservoir of Fig. 1 on AB;

Figure 4 is a cross-section through an automatic coupling for the supply and withdrawal of fluid cargo to or from the reservoir and for the connection of services such as electricity and compressed air, fitted to the base of the reservoir of Figs. 3 and to the same scale;

Figures 5a and 5b are diagrammatic cross-section through two arrangements for combining storage and water-ballast tanks;

Figures 6a, 6b and 6c are diagrammatic representations of two methods for dividing a storage vessel into two variable volume chambers to facilitate the use of part of the storage for water ballasting, Figs. 6a representing one method, and Figs. 6b and 6c the second method with the storage vessel containing different amounts of fluid cargo;

Figures 7a, 7b and 7c are diagrammatic representations of two methods for storing a gas at high pressure in a storage vessel shown in cross-section in Figs. 7a and 7b with part Fig. 7c being a representation of pipework in Fig. 7b;

Figure 8 is a sectional plan for one kind of berth that can be moored underwater to receive submersible reservoirs and other modular facilities;

Figure 9 is a cross-section to the same scale through the underwater berth of Fig. 8 on EF; and

Figure 10 is a cross-section to a larger scale through the underwater berth of Fig. 8 on GH.

Figs. 1 to 4 inclusive show an example of a submersible reservoir in which pluralities of storage vessels 1, water-ballast tanks 2, and buoyancy tanks 3, numbering fourteen, six, and four respectively in this example, and a central control chamber 4, are all encased in concrete 5. The concrete may be reinforced or prestressed and may be contained within a casing 6, which for the scale of the drawings is of insufficient thickness to appear as a separate entity. The casing 6 may be made of any suitable material. The casing, where provided, protects the concrete against deterioration in sea water, and provides part of the structural strength. The same materials are preferred for the construction of the vessels and tanks 1, 2, and 3. The water-ballast tanks 2 are designed to receive and expel ballast-water so that what is held at any time is reasonably distributed along the length and across the breadth of the reservoir. Buoyancy tanks 3 are incorporated as necessary to adjust the buoyancy and the distribution of weight in the design of the reservoir. The arrangement of vessels and tanks within the concrete structure and the overall shape of the concrete structure is such that when floating fully submerged the reservoir has stable equilibrium when empty, and preferably when full or partly full or cargo. For transporting a cargo of liquid or slurry it may be necessary or desirable for each individual storage vessel to be full or empty or close to either condition so that the centre of buoyancy will not move significantly with movement of the cargo, with any empty vessels uppermost so that the stability of the reservoir is not impaired.

The example of a submersible reservoir here presented has a tow line 7 attached to a towing eye 8 which is attached by ties 9 to achorage points 10 set within the concrete in such a way that any force exerted by the tow-line 7 is transmitted to the concrete structure without damage. In this example, an energy-absorbing shield 11 is provided which may be duplicated at the other end of the reservoir, to give some protection against accidental damage. Preferably the shield 11 is constructed in such a way that it has little or no submerged weight and can be bolted together around the ties 9 and bolted to the concrete. Preferably, the reservoir is elongate in form with substantially a uniform cross section throughout its length as in the example, and which preferably is of a smooth rounded cross-section as in the example.

Services and control lines 12, such as for supplying electricity, compressed air, or fuel as necessary, and for controlling remotely any functioning parts of the reservoir may be attached loosely to the tow-line 9 in such a way that any tension in the tow-line is not transmitted to the service and control lines 12. The service and control lines may be fed through a duct 13 to the control chamber 4 from which service lines and control lines to a propulsion unit (if fitted and not shown) may be fed through a corresponding duct 14. Further ducts to feed services and controls as necessary may connect the control chamber 4 to any guidance means such as a rudder, elevators for controlling depth and pitch in the water, and water jets that are controllable in intensity and direction. Remote control and the supply of services to the control chamber 4 may be provided alternatively or additionally through a socket connection 15, which carries service lines 16, which in this example is located beneath the control chamber 4, and alternatively or additionally may be located in a suitable position above the control chamber. Socket connections 17 for pipes 18 to feed a cargo of fluid to or from the reservoir are located likewise at the top or bottom of the control chamber 4, or at both top and bottom as in the example. Pipes 19 shown discontinuously in the example connect the sockets 17 to pipes 20 leading to the storage vessels 1 via pumps and stop valves as required, lo-

cated in the control chamber 4. The cargo feed pipes 18 and the services line 16 may be linked together in a block or other form of structural connection to form a combined plug 21 for connecting fluid cargo feed lines and services to the reservoir. The combined plug 21 is held by springs 22 or other form of resilient mounting such as a block of synthetic rubber so that if the reservoir settles down on the plug 21, watertight connections are made automatically to the bottom of the reservoir without risk of damage to the sockets 15, 17 and without risk of damage to the plug 21. Similarly, connections may be made automatically at the top of the reservoir if the reservoir is positioned underneath a similar kind of plug and rises to engage it. Alternatively, the connections may be made manually and individually if required. Walter-ballast is fed to or from the reservoir through intakes 23, and pipes 24 shown discontinuously in the example. The pumps and valves (not shown) for controlling the amount of ballast water, in addition to being operated by remote control may also be operated automatically by transducers measuring as necessary, stress, deformation, and bearing pressure at suitable positions in the reservoir or in or on anything in contact with the reservoir such as a cradle or submerged platform. An access chamber 25 which may or may not serve as a decompression chamber is provided for access by maintaining personnel, and if required, a second such access chamber may be provided in a suitable position at the bottom of the control chamber 4.

The reservoir may be constructed by methods normally used to build reinforced or prestressed concrete structures, including construction with pre-cast concrete units that are prestressed by means of post-tensioned cables and grouted to form a composite structure. The use of pre-cast concrete construction is particularly suited to the construction of a submersible reservoir of a kind shown in the example. The structure could be divided into units by a number of cross-sectional planes such as CD in Fig. 1, uniformly spaced along its length. In this way a submersible reservoir could be formed with one central unit containing the control chamber 4, two end sections incorporating the shaped ends of the tanks, and a plurality of uniform intermediate sections that may be varied in number to produce submersible reservoirs of different capacities for different uses.

The example of a submersible reservoir here presented incorporates storage tanks 1, water-ballast tanks 2, and buoyancy tanks 3 that are separate entities and that are of a preferred cylindrical form suited to receive fluids at elevated pressures. In some circumstances a suitable arrangement of such vessels and tanks within a given volume of concrete may be difficult or impossible to achieve, and alternative forms may have to be employed. It may be possible to preserve cylindrical forms, in essence, by joining together cylinders and parts of cylinders. Figs. 5a and 5b are representative cross-sections of two such combinations in which storage vessels or tanks 26, 27, are brought together as necessary.

A submersible reservoir to contain a cargo of liquid or slurry may require water-ballast tanks with a proportionately larger total volume than is shown in the example. In order to employ the materials of construction more effectively and to reduce the size of the ballast-tanks required, it may be advantageous to incorporate some of the water-ballasting within the storage vessels, in the space not occupied by the liquid or slurry. To do this the water-ballast and the fluid cargo may be separated by a slack, impervious, flexible membrane, and two ways in which this may be done are shown diagrammatically in Figs. 6a, 6b and 6c. In Fig. 6a a flexible membrane 28 with a bulbous rim 29 is sealed into a groove in the walls of the storage vessel by means of a plate 30 held in place by screws 31. Two variable-volume chambers 32, 33, are so formed either of which can be made to occupy substantially the whole of the storage vessel 34. In this example the membrane is sealed into the walls of the storage vessel where a horizontal plane of symmetry intersects the inside of the walls, but this need not necessarily be so. For example, assuming that in Figs. 5a and 5b item 27 represents a storage vessel, a slack membrane could be sealed into it where it joins the vessel or tank 26 and which would operate successfully with less rucking of the membrane than in the example given in Fig. 6a. For the example of another method of sub-division shown in Figs. 6b and 6c, a flexible impervious bag 35 is contained within a storage vessel 36, the bag being of the same shape and dimensions as the inside of the vessel. One variable-volume chamber 37 is formed inside the bag, and another such chamber 38 is the space not occupied by the bag. Fig. 6c when compared with Fig. 6b shows how the bag 35 should fold back on itself as the chamber 38 increases in volume. To achieve this it may be necessary to reduce the flexibility of the half of the bag remaining in contact with the inside wall of the storage vessel. Although a flexible bag requires approximately twice the amount of material required for a sealed-in membrane, it has the advantages that it can be replaced more easily, more quickly—and more cleanly if a dirty cargo is contained within the bag. Suitable access to the vessel is required for the replacement of any membrane or bag. For the example of a submersible reservoir herein, this could be provided through tunnels in the shield 11 into the outer ends of the vessels. To avoid the need to put the reservoir into a dry dock for the replacement, a specially designed chamber

could be sealed temporarily to the end of the reservoir and pumped out to give dry access when the reservoir is floating at the surface of the water.

The introduction of water-ballast into the storage tanks not only reduces the size of water-ballast tanks that are necessary, but also it has a significant effect on the design of the structure of the reservoir for cargos of liquids and slurries, certainly for those with densities close to or exceeding that of the ballast water and with decreasing probability as the cargo density decreases depending on the relative cost of construction. With the exclusion of air or any substituted gas from the space in the storage vessel not occupied by the cargo, if the cargo is close to or greater than that of the ballast water a light structure is required that may need the addition of buoyancy tanks to produce the appropriate submerged weight. Consequently for such cargos and if ballast water is taken in to the storage tanks, a light rigid framework is substituted for some or all of the concrete. The casing, 6 in the example, may be retained as part of the structure and to give stream-lining if the reservoir is to be towed. For cargos with a density greater than that of the ballast water, it is necessary to expel water from the water-ballast tanks to balance an increase in the amount of cargo whereas for cargos with lower density the amount of ballast water is increased. For a cargo of gas, the division of a storage vessel will not normally be required, but this may be advantageous in some circumstances, for example as a means of expelling the remains of one gas before admitting another.

A cargo of gas is held in the storage vessel under pressure which increases as the vessel is filled. Successive loading and unloading of the cargo will subject the storage vessel to repeated stressing. Either the storage vessel and the surrounding structure must be designed against fatigue, or the storage vessel must be replaceable and the structure isolated from these stresses. Two ways in which this can be done are shown diagrammatically in Figs. 7a, 7b, and 7c. In Fig. 7a the gas is contained in a storage vessel 39 inside a jacket 40 held by rollers 41, and 42, and by rubber blocks at the ends (not shown). The rollers 42 are mounted on rubber blocks which together with the end blocks allow the storage vessel to expand without significant restraint, while holding the vessel firmly inside the jacket. The rollers 42 enable the storage vessel to be pushed into and withdrawn from the jacket from one end. For the example of a submersible reservoir presented herein suitable access would be required from the ends through watertight doors. The second method, shown diagrammatically in Fig. 7b and 7c differs from the first in that the gas is contained within a continuous pipeline 43 folded end to end inside the jacket 44. Fig. 7c is a diagrammatic end view of the centre line of the pipeline 43, with U-bends connecting straight lengths together at the near end shown by unbroken lines, and corresponding connections at the far end shown by broken lines. Other arrangements of connections are possible. In this example there are eighteen straight lengths of pipe, and any suitable even number may be used so that the two ends 45 of the pipeline 43 are at the same end of the jacket and may be anchored to it where the two ends pass through. The bundle of the straight lengths of the pipeline 43 is fixed to a plurality of supporting frames 46 at intervals along the length, fixings being possible because all of the straight lengths will extend by the same amount together, with one end of the bundle of pipes unrestrained. Roller bearings 47 allow the frames to move unrestrained in the longitudinal direction but the bundle is restrained transversely.

Air or an inert gas, whose pressure may be monitored to detect leaks in the storage vessel, can be provided within the space between jacket 40 and storage vessel 39 (Fig. 7a) or between jacket 44 and pipeline 43 (Fig. 7b).

Figs. 8, 9 and 10 give an example of a buoyant platform 48 held underwater by tethers 49 with two submersible reservoirs 50 having a net buoyancy and two representations of modules 51 such as production modules with access chambers 52 having a net submerged weight, the whole assembly have a net buoyancy. The platform has built-in buoyancy tanks 53 and access tunnels 54 within which are installed connecting links 55 for supply pipes, services, and controls shown in representative form only in Fig. 10. A buoy 56 enables shuttle tankers to connect to the underwater system, or tankers that can lower a riser and connect to the platform remotely —as considered for the Single Well Oil Production System (SWOPS) might be used.

CLAIMS

1. A reservoir for storage or transportation of a fluid, comprising at least one vessel for receiving the fluid, means for allowing the fluid to be supplied to and withdrawn from the vessel or vessels, and at least one ballast tank, the ballasting being such that regulation of the amount of ballast permits the reservoir selectively to float or sink when the vessel or vessels is or are empty.

2. A reservoir according to claim 1, wherein the ballasting is such that regulation of the amount of ballast permits the reservoir selectively to float or sink when the vessel or vessels is or are full.

3. A reservoir according to claim 1, wherein the ballasting is such that regulation of the amount of ballast permits the reservoir to maintain a small positive or negative buoyancy during supply or withdrawal of fluid.

4. A reservoir according to claim 3,

wherein the regulation of the amount of ballast is effected automatically in response to a measured parameter.

5. A reservoir according to claim 3, wherein the regulation of the amount of ballast is effected remotely.

6. A reservoir according to any preceding claim, which is of elongate form and in which the vessel or vessels and tank or tanks are present over substantially the whole length of the reservoir.

7. A reservoir according to any preceding claim, which further comprises at least one buoyancy tank.

8. A reservoir according to any preceding claim, wherein the vessel or vessels and tank or tanks are encased in a body of concrete.

9. A reservoir according to claim 8, wherein the concrete is reinforced or prestressed.

10. A reservoir according to claim 8 and 9, wherein the body of concrete is surrounded by an outer casing.

11. A reservoir according to any preceding claim, provided with means for enabling the reservoir to be towed.

12. A reservoir according to claim 11, wherein the reservoir is capable of being towed below the surface and is provided with means for controlling the towing depth.

13. A reservoir according to any preceding claim, which is provided with propulsion means for providing a propulsive force to the reservoir.

14. A reservoir according to claim 13, wherein the propulsion means are capable of applying a reverse thrust.

15. A reservoir according to any preceding claim, which comprises a plurality of sections held together end to end.

16. A reservoir according to claim 15, comprising a central section housing control means for the reservoir, an end section at each end, and at least one intermediate section located between the central section and each end section, and housing the vessel or vessels and tank or tanks.

17. A reservoir according to claim 16, wherein at least one of the end sections provides an energy absorbing shield.

18. A reservoir according to any preceding claim, wherein means are provided to divide at least one of the vessels into two chambers of variable size, one chamber serving to receive the said fluid and the other chamber serving to receive ballast.

19. A reservoir according to claim 18, wherein the dividing means comprises a flexible, impervious bag defining one of the chambers inside it and the other of the chambers outside it.

20. A reservoir according to claim 19, wherein the bag is removably mounted.

21. A reservoir according to claim 18, wherein the dividing means comprises a flexible, impervious membrane.

22. A reservoir according to any preceding claim, comprising means enabling the reservoir to be lifted.

23. A reservoir according to any preceding claim, provided with a socket adapted to receive a connector which carries the said fluid to and from the reservoir.

24. A reservoir according to any one of claims 1 to 22, provided with a socket adapted to receive a connector which carries services to the reservoir.

25. A reservoir according to any one of claims 1 to 22, provided with a socket adapted to receive a connector which both carries the said fluid to and from the reservoir and carries services to the reservoir.

26. A reservoir according to any preceding claim, wherein the vessels and/or tanks are provided by containers which, in cross section, appear as a cylinder and at least one part cylinder joined together.

27. A reservoir according to any preceding claim, wherein the or each storage vessel is mounted in a jacket which is spaced therefrom.

28. A reservoir according to any one of claims 1 to 26, wherein the storage vessel or plurality of storage vessels is defined by a pipe which runs in a sinuous path backward and forward along the reservoir.

29. A reservoir according to claim 28, wherein the pipeline is mounted on rollers to permit longitudinal extension thereof.

30. A reservoir according to any preceding claim, wherein means are provided for monitoring the pressure of a gas or air within the reservoir, thereby to detect any leakage of fluid from the storage vessel or vessels.

31. A reservoir according to any preceding claim, which is provided with means affording access of personnel to the interior thereof.

32. A reservoir for the storage or transportation of a fluid, substantially as herein described with reference to any one of the embodiments shown in Figs. 1 to 7 of the accompanying drawings.

33. A berth for receiving a reservoir according to any preceding claim, comprising a structure to which the reservoir can be anchored and which has means for receiving the said fluid from or supplying the said fluid to the reservoir.

34. A berth according to claim 33, which is in the form of a platform.

35. A berth according to claim 34, wherein the platform is a buoyant, tethered platform.

36. A berth according to claim 34 or 35, wherein at least one anchorage is provided on the upper side of the platform.

37. A berth according to any one of claims 34 to 36, wherein at least one anchorage is provided on the lower side of the

platform.

38. A berth according to any one of claims 33 to 37, which is provided with means affording access of personnel to the interior thereof.

39. A berth substantially as herein described with reference to Figs. 8 to 10 of the accompanying drawings.

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